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# UNEXPECTED ECONOMIC LOSS FROM YIELD VARIATION AND FEDERAL CROP INSURANCE

by

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# UNEXPECTED ECONOMIC LOSS FROM YIELD VARIATION AND FEDERAL CROP INSURANCE

Multiple Peril Crop Insurance (MPCI) and Group Risk Plan (GRP) use yield (i.e., physical) loss to determine who collects. However, insurance is bought to protect against economic loss resulting from physical loss. This study analyzes unexpected economic loss resulting from yield variation. It also compares unexpected economic loss with simulated MPCI and GRP collections for a sample of Ohio farm operators. Analysis reveals: (1) GRP's payout structure is further removed from unexpected economic loss than MPCI's, (2) MPCI collections exceed the associated unexpected economic loss in a free market, and (3) MPCI collections more closely match unexpected loss when farm programs exist.

# UNEXPECTED ECONOMIC LOSS FROM YIELD VARIATION AND FEDERAL CROP INSURANCE

Collections under existing federal crop insurance programs are determined by yield (i.e., physical) loss. However, insurance is an economic good bought to protect against the economic loss which results from physical loss, not against physical loss <u>per se</u> (Williams, <u>et al</u>., p. 107). This distinction between economic and physical loss becomes critical in a competitive market where physical loss can be widespread. The largest cause of crop loss in the U.S. is drought (U.S. Department of Agriculture (USDA), 1992, p. 398). Drought usually affects a large geographical area at one time. Thus, economic loss associated with yield loss for an individual operator is often a function of not only the individual operator's yield loss, but also the change in market price engendered by a concurrent wide-spread natural phenomenon.

This study examines the unexpected economic loss associated with yield variation. Models of unexpected economic loss associated with yield variation are derived (1) for a market situation in which there are no public price and income support programs (hereafter, referred to as the free market scenario) and (2) for a market situation in which the government provides farm income deficiency payments and price support loans (hereafter, referred to as the farm program scenario). Data from a random sample of Ohio farm operators for 1986, 1987, 1988, and 1990 are used to calculate unexpected economic losses (and gains) resulting from yield variation in corn under both scenarios. The unexpected economic losses are compared with insurance collections simulated in accordance with Federal Multiple Peril Crop Insurance and Group (i.e., area) Risk Plan. Conclusions, implications, and suggestions for future research end the paper.

## UNEXPECTED ECONOMIC LOSS MODELS

A farm operator decides to plant a crop based on expected revenues. If realized revenue is less (greater) than expected revenue, the farm operator experiences an unexpected economic loss (gain). Characteristics of unexpected economic loss resulting from variation in yield are modeled for U.S. field crops. The model is developed initially for a free market. Then, the impact of government price and income supports is evaluated.

### Free Market

In a free market, a farm operator's gross revenue expected at the time the crop is planted[1] equals:

$$(1) \quad GR_i^e = P_m^e \bullet Y_i^e \bullet A_i^e$$

where: $GR^e_i$ = Expected Gross Return for Farm Operator i
$P^e_m$ = Expected Market Price at Harvest[1]
$Y^e_i$ = Expected Average Yield per Acre
$A^e_i$ = Expected Harvested Acres

Actual realizations of the above variables are denoted by dropping the superscript *e* (e.g., realized gross return is represented as $GR_i$). Assuming expected cost equals realized cost, a farm operator is better off than expected at planting if $GR^e_i < GR_i$.

The focus of this analysis is the change in gross revenue from that expected at planting when realized yield differs from expected yield. Therefore, assume that realized harvested acreage equals expected harvested acreage. Consequently, whether a farm operator realizes an unexpected economic loss or gain, i.e., is worse or better off than expected at planting, can be determined as follows:

$$(2) \quad P_m^e \bullet Y_i^e \gtrless P_m \bullet Y_i$$

If both realized price and yield exceed (are less than) expected price and yield, then the farm operator's gross revenue is unexpectedly higher (lower). The direction of change in gross revenue is uncertain when, relative to their expected values, realized price and yield move in opposite directions. This situation can be examined by reformulating equation 2 in terms of percentage change:

$$(3) \quad \%\Delta P_m \gtrless \%\Delta Y_i$$

$$\text{where:} \quad \%\Delta P_m = (P_m - P_m^e) \; / \; [(P_m + P_m^e) \; / \; 2]$$
$$\%\Delta Y_i = (Y_i - Y_i^e) \; / \; [(Y_i + Y_i^e) \; / \; 2]$$

Most crops are produced in a competitive market where individual farm operators can not influence the market price at harvest and, therefore, are a price takers. Thus, ignoring price differences caused by spatial factors, all operators receive the same price.

Market price can change due to a variety of supply and demand considerations. Because this study focuses on the consequences of yield variation upon unexpected economic loss or gain, it is necessary to identify the change in market price which is solely due to a change in yield. Therefore, assume that the market demand curve is a constant elasticity of substitution function and remains constant between planting and harvest, that national harvested acres do not differ from expected, and that imports are negligible. Given these assumptions, market price changes only when the supply curve shifts along the demand curve in response to changes in national average yield.

Magnitude of the price change is a function of the elasticity of demand and the change in national average yield (i.e., supply curve shift). Specifically,

$$(4) \quad \%\Delta P_m = (1 / \varepsilon_D) \bullet \%\Delta Y_N$$

$$\begin{aligned} \textit{where: } \varepsilon_D &= \textit{Elasticity of Demand} \\ Y_N &= \textit{Average National Yield} \\ \%\Delta Y_N &= (Y_N - Y_N^e) / [(Y_N + Y_N^e) / 2] \end{aligned}$$

Since the elasticity of demand is negative, market price increases (decreases) if national yield declines (increases) relative to its expected value at planting.

Substituting equation 4 into equation 3 results in:

$$(5) \quad (1 / \varepsilon_D) \bullet \%\Delta Y_N \gtrless \%\Delta Y_i$$

Examination of this equation reveals that in a free market a decline in a farm operator's yield between planting and harvest translates into an unexpected economic loss only if the percentage decline in the operator's yield is greater than the percentage decline in the national yield adjusted for the demand price flexibility (i.e., one over the elasticity of demand). Therefore, a farm operator with an unexpected physical loss (i.e., decline in yield relative to expected) does not necessarily suffer an unexpected economic loss (i.e., decline in gross revenue relative to expected). Furthermore, a farm operator whose realized yield exceeds expected yield also can suffer an unexpected economic loss if the percentage increase in his/her yield is less than the percentage increase in the national yield adjusted for the demand price flexibility.

If the realized and expected national yields are the same, $\%\Delta Y_N$ in equation 5 equals zero. Only in this situation will unexpected economic loss depend solely on the unexpected yield loss of the individual farm operator.

Farm Price and Income Support Program

For cotton, feed grains, rice, and wheat the government provides price supports via nonrecourse loans and income support via deficiency payments. Nonrecourse loans establish a floor on market price. Deficiency payments establish a minimum revenue per bushel (i.e., target price) for eligible crops. To establish eligibility, a specified percent of land must be set aside (i.e., not planted).

Abstracting away from payment limits, gross income for farm operator i at planting time for an acre of planted land enrolled in farm price and income support programs during the years examined in this study equalled[2] (USDA, 1990):

$$(6) \qquad GR^e = MAX(P^e_m, LR) \bullet Y_i + MAX[0, TP - MAX(LR, DPP^e)] \bullet PPY_i$$

where: $GR^e$ = Expected Gross Return per Acre of Planted Land in Farm Program
$LR$ = Loan Rate
$TP$ = Target Price
$DPP^e$ = Deficiency Payment Price
$PPY_i$ = Program Payment Yield

Maximum per bushel deficiency payment is the difference between the target price and nonrecourse loan rate. The loan rate, target price, and operator's program payment yield are known at planting time.

For a producer participating in the farm program, unexpected economic loss (gain) from yield variation must include the resulting unexpected changes in deficiency payments between planting and harvest and the effect of the nonrecourse loan rate on price received. To illustrate the implication of this observation, assume expected market price is greater than the loan rate but less than the target price. Also assume that a farm operator's expected yield and program payment yield are equal and that changes in market price and deficiency payment price are perfectly positively correlated. Therefore, unexpected changes in market price and deficiency payment caused by unexpected changes in national yield completely offset each other. Consequently, the operator's unexpected economic loss is a function only of unexpected change in his/her yield. While these assumptions will not hold in the real world, it is reasonable to expect that the effect of an unexpected change in national yield upon market price can be offset at least partially by an opposite unexpected change in deficiency payment. Consequently, unexpected economic loss from yield variation can differ significantly between the free market and farm program scenarios[3].

## PARAMETERIZATION OF UNEXPECTED ECONOMIC LOSS CALCULATIONS

Analysis of a farm operator's unexpected economic loss associated with yield variation requires the measurement of expected and realized values for individual farm operator yield and national yield. In addition, the relationship between changes in national yield and changes in market price needs to be identified. The specific crop for which these variables and relationship are identified is corn.

### Individual Farm Operator Yields

Individual farm operator yields are taken from the Ohio Farm Household Longitudinal Survey. Data from this survey exist for 1986, 1987, 1988, and 1990 (no survey exists for 1989). The survey collected data from a randomly selected sample of approximately 1,000 Ohio farm operator households during the spring of the following calendar year. Some households included in the 1987, 1988, and 1990 surveys participated in earlier samples; other households were replacements.

One hundred eighteen farm operators reported corn yields for 1986, 1987, 1988, and 1990. During the 1990 survey they also reported corn program payment yield for 1991 and expected 1991 corn yield.[4] These 118 farm operators comprise the sample analyzed in this investigation.

Program payment yields have been frozen at 1986 levels since passage of the *Food Security Act of 1985*. Thus, the farm operator's corn program payment yield for 1991 is used for the 1986, 1987, 1988, and 1990 crops. Expected yield is available only for 1991. To account for technological change, this yield is adjusted to earlier years by using the trend in average expected Ohio yields over the period of analysis. Average expected Ohio yield for 1986, 1987, 1988, 1990 and 1991 is calculated as the average of Ohio yields for the five previous crop years minus high and low yields. The ratio between the estimated Ohio expected yields for an earlier year and 1991 is multiplied by the individual farm operator's 1991 expected yield to create an adjusted expected yield for the earlier year. For example, using this procedure the 1986 Ohio expected yield is 8.7 percent less than the 1991 Ohio expected yield. Accordingly, each farm operator's 1991 expected yield is reduced by 8.7 percent to derive the operator's expected yield for 1986.

National Yield and Market Price

Realized U.S. yield is the yield reported in USDA's November crop production report. The November report occurs during the peak of corn harvest in the U.S. and

Ohio. The yields are 119.3, 120.3, 82.3 and 119.0 bushels per acre for 1986, 1987, 1988, and 1990, respectively.

Expected U.S. yield at planting for 1986, 1987, 1988, and 1990 is calculated as the moving average of national yields for the five previous crops minus high and low yields[5]. This estimator generates national expected harvest yields of 109.6, 112.6, 114.7, and 117.9 bushels per acre, respectively. Therefore, realized national yield differs from expected national yield by 9.7, 7.7, -32.4, and 1.1 bushels per acre for 1986, 1987, 1988, and 1990, respectively.

Expected Ohio harvest price equals the December corn futures price on April 1 minus the average Ohio corn basis during the five previous crop harvest periods. The basis for a given year is the average of the basis for all Tuesdays between October 15 and November 15, which is the period of peak corn harvest in Ohio. The basis equals the closing Chicago Board of Trade December futures prices minus average Ohio cash price. In summary, this procedure generated expected harvest-time cash corn prices of $1.84 in 1986, $1.55 in 1987, $2.04 in 1988, and $2.42 in 1990.

Because the planting season in Ohio begins approximately April 15, April 1 falls late in the planted acreage decision. Thus, the chance that planted, hence harvested acreage will vary from expectations is minimized by using this date.

Futures prices for corn are obtained from a computer database compiled by Technical Tools. Cash prices are obtained from the Ohio Department of Agriculture.

The relationship between the change in U.S. yield between planting and harvest and the corresponding change in the value of corn is derived by regressing the percentage change in the December corn futures price from May 15 to November 15 on the percentage change from expected values over this period for the following market factors: new crop yield, new crop harvested acres, and stocks carried into the new crop year[6]. May is the earliest month for which new crop supply and demand estimates are consistently available from USDA's *World Supply and Demand Estimates*. As previously mentioned, the November report occurs during the peak of corn harvest in the U.S. and Ohio.

Percentage change in U.S. yield is calculated using the previously discussed expected and harvested yields. Percentage change in new crop carryin stocks is calculated using the values reported in the May and November *World Supply and Demand Estimates*. Percentage change in harvested acreage is calculated using the estimated planted acreage in the May report and harvested acreage reported in the November report. The estimated planted acreage reported in May is adjusted to an estimated harvested acreage by using a historical five year moving average of the ratio between harvested and planted acres.

The first year that estimates for new crop supply and demand are available in May is 1974. Using only data from previous years, the regression results for each year are:

$$\begin{aligned}
(7) \quad & 1986: \quad \%\Delta P_m = -0.01 - 0.78\ \%\Delta Y_N + 2.14\ \%\Delta Acres - .35\ \%\Delta stocks \\
& 1987: \quad \%\Delta P_m = -0.01 - 0.80\ \%\Delta Y_N + 2.20\ \%\Delta Acres - .34\ \%\Delta stocks \\
& 1988: \quad \%\Delta P_m = -0.02 - 0.80\ \%\Delta Y_N + 2.28\ \%\Delta Acres - .32\ \%\Delta stocks \\
& 1990: \quad \%\Delta P_m = -0.02 - 0.82\ \%\Delta Y_N + 2.18\ \%\Delta Acres - .32\ \%\Delta stocks
\end{aligned}$$

All four yield coefficients are significant at the one percent level. $R^2$ for the 1986, 1987, and 1988 regressions is 0.74, while $R^2$ for the 1990 regression is 0.76. The price change coefficient is approximately -0.8 for all four regressions. This coefficient implies that a one percentage increase (decrease) in national yield relative to that expected at planting is associated with a 0.8 percentage decrease (increase) in the December corn futures price between May 15 and November 15[7].

Percentage change in U.S. yield between planting and harvest, the December corn futures price at planting, and the estimated price change coefficient can be used to solve for the harvest-time value of the December corn futures contract associated with the change in national yield. An Ohio value is derived by subtracting the average Ohio corn basis during the five previous harvests[8]. This procedure generates the following yield-adjusted value of Ohio corn at harvest: $1.70, $1.46, $2.72, and $2.40 for 1986, 1987, 1988, and 1990, respectively. These yield adjusted values differ by -14, -9, 68, and -2 cents, respectively, from their expected values at planting.

Per Bushel Deficiency Payment Calculations

Expected per bushel deficiency payment at planting equals the target price for the specific year minus the higher of that year's (1) nonrecourse loan rate or (2) the expected average U.S. cash price over the first five months of the corn marketing year (i.e., expected deficiency payment price for corn). This expected price is estimated as: (December corn futures price on April 1) minus (average difference for the five previous years between the December corn futures price on November 15 and average U.S. cash corn price from September through January). Using this procedure, per bushel deficiency payment expected at planting is $1.11 in 1986, $1.21 in 1987, $0.91 in 1988, and $0.33 in 1990.

The cash price used to determine the deficiency payment expected at harvest after adjusting for changes between expected and realized national yield equals: (value of the December futures contract associated with the change in national yield between planting and harvest) minus (average difference for the five previous crop years between the December corn futures price on November 15 and the average U.S. cash price for the September - January period). This procedure generates the following per bushel deficiency payments expected at harvest: \$1.11 in 1986, \$1.21 in 1987, \$0.23 in 1988, and \$0.36 in 1990.

## Results for Unexpected Economic Loss Analysis From Yield Variation

Due to favorable weather, realized yield exceeded expected yield in 1986 for 91 percent of the 118 Ohio farm operators examined in this study (Table 1). In contrast, drought during 1988 resulted in 69 percent of the operators having a realized yield which was at least 25 percent below expected yield. In 1987, realized yield is slightly skewed toward being greater than expected yield, while the opposite is true in 1990.

Consistent with the conceptual model, the distributions of percent unexpected change in an individual farm operator yield (actual yield divided by expected yield) and the corresponding percent unexpected change in gross return (gross return after adjusting for farm operator and national yield changes divided by expected gross return) differ substantially in the free market scenario. In 1988, only 37 percent of the farm operators had an unexpected economic loss greater than 25 percent in the free market scenario (Table 2). This share is 32 percentage points less than the share of farm operators who had a yield loss greater than 25 percent. The difference occurs because a national drought caused realized national yield to be 28 percent below expected national yield. Therefore, the value of a bushel of corn increased to reflect the smaller supply.

In 1986 and 1987, a nine and seven percent increase in national yield relative to that expected at planting meant the opposite situation occurred in the free market. Nine and forty-two percent of farm operators had a realized yield which was lower than the expected yield in 1986 and 1987, respectively. In contrast, 20 and 64 percent of the operators experienced an unexpected economic loss in 1986 and 1987, respectively.

In 1990, the distributions for unexpected yield change and unexpected change in gross revenue are almost identical in the free market scenario because realized and expected national yield are nearly identical (119.0 vs 117.9 bushels per acre). Thus, as expected in this situation, unexpected economic loss (gain) is predominately a function of unexpected change in the individual farm operator's yield.

Except for 1990, when realized and expected national yield were almost identical, the distribution of percent unexpected economic loss differed between the farm program and free market scenarios. The greatest difference occurred in 1988 when realized national yield differed substantially from expected. Sixty-two percent of farm operators in the farm program scenario had an unexpected economic loss which exceeded 25 percent. The comparable share of farm operators in the free market scenario was 37 percent. This difference reflects an unexpected decline in deficiency payments of \$0.68 per bushel in response to the lower national yield caused by the drought.

During 1988, the distribution of unexpected economic change in the farm program scenario closely mirrored the distribution of unexpected changes in the individual farm operator yields (Tables 1 and 2). This similarity occurred because the unexpected changes in market value and deficiency payment due to an unexpected decline in national yield largely offset one another. Differences still occurred because a farm operator's corn program payment yield differed from expected and actual yield[9].

In conclusion, in the free market scenario substantive differences can exist between the percent unexpected change in an individual farm operator's yield and the associated unexpected economic loss or gain caused by yield variation. This difference occurs because unexpected change in gross revenue incorporates the unexpected variation in both the individual farm operator's yield and the unexpected contemporaneous variation in national average yield. Hence, unexpected economic change associated with yield variation contains within its calculation the market-wide risk factor of an unexpected change in national yield. Inclusion of this systematic factor raises the potential for significant implications for crop insurance because insurance is bought to protect against the economic loss resulting from yield loss, not against yield loss per se.

Unexpected economic loss also can differ substantially between the free market and government program scenarios. This finding suggests that insurance programs which recognize this difference might be desirable.

## CROP INSURANCE SIMULATIONS

The implications for crop insurance are investigated by comparing the simulated collections under current federal crop insurance programs with the associated unexpected economic loss. Current programs are Multi-Peril Crop Insurance (MPCI) and the Group Risk Program (GRP). MPCI, which was first offered in 1938, covers most major field crops for unavoidable production losses caused by drought, hail, flood, and other natural disasters. A pilot project for GRP was initiated in 1993 for soybeans in selected counties and states. This pilot project will be expanded in 1994 to other crops and areas. GRP is based on county yields, not individual farm operator yields. Thus, it provides insurance against widespread loss of production in a county.

Collections Under Multiple Peril Crop Insurance

Under MPCI, a farm operator collects if actual yield for the year falls below guaranteed yield. Guaranteed yield equals (Lovell and Smith, p. 1):

(8) MPCI Guaranteed Yield = APH Yield • Coverage Level

where: APH Yield = Estimate of farm operator's 10 year average yield[10]
Coverage Level = Choice of 35, 50, 65, and 75 percent

If actual yield is less than the guaranteed yield, collection under MPCI equals:

(9) MPCI Collection = (Guaranteed Yield - Actual Yield) • Payment Price

where: Payment Price = Choice between 30 and 100 percent of MPCI established price or MPCI announced market price, whichever is greater (Cross and Crane, p. 3).

Collections Under Group Risk Plan

Under the soybean GRP, collections occur if the county's actual yield falls below the county's trigger yield. County trigger yield equals (USDA, 1992, p. 9):

(10) GRP Trigger Yield = Coverage Level • Expected County Yield

where: Coverage Level = Choice of 65, 70, 75, 80, 85, or 90 Percent
Expected County Yield = Average of historical county yields adjusted for advances in technology (Skees, et al., p. 17).

If the realized county yield is below the trigger yield, the following amount is collected per covered acre (Skees, et al., p. 8):

(11) GRP Collection = [(Trigger County Yield - Actual County Yield) / Trigger County Yield] • Protection Level

where: Protection Level = Choice between 30 and 100 percent of maximum protection per acre for the county (USDA, 1992, p. 9). Maximum protection is 150 percent of average county revenue per acre.

Insurance Parameter Estimates

The 1993 format of the GRP program for soybeans is used for corn. Coverage levels for MPCI and GRP are specified as 75 and 90 percent, respectively. These are the highest level currently available for each. The use of a higher coverage level for GRP reflects its lower level of adverse selection (Miranda).

The farm operator's expected yield for a year is used as the APH yield since actual APH yields are not available. This decision enhances comparability between MPCI insurance collection and unexpected economic loss. Also for comparability reasons, expected harvest cash price on April 1 is used as the MPCI payment price.

Expected county yield for each year is calculated as a moving average of the county's yields for the previous five years after eliminating the high and low yields. This procedure is the same one used for calculating expected U.S. and Ohio yields.

The GRP protection level selected for each year is defined as the expected harvest cash price on April 1 times expected yield. Thus, the protection level equalled the farm operator's expected gross revenue for the crop year.

## Results for Insurance Collection Analysis

Over all four years, 20 percent of the observations resulted in MPCI insurance being collected at the 25 percent deductible level. Because eligibility for collecting under MPCI depends on the ratio between realized and expected yield, this proportion can be derived directly from Table 1. Eighty-eight percent of MPCI collections occurred during the drought year of 1988.

Under GRP, 28 percent of the observations resulted in insurance being collected at the 10 percent deductible level. All 118 farm operators collected in 1988. In other words, the 1988 realized average yields for all Ohio counties represented in this study were at least 10 percent below their expected yields.

Of the 93 times MPCI insurance is collected in the free market scenario, 41 percent are associated with an unexpected economic loss which is less than 25 percent (Table 3). Average insurance collected in these 38 situations is $25.79 per acre even though unexpected economic loss is less than 25 percent. Furthermore, when both MPCI insurance is collected and unexpected economic loss exceeds 25 percent, average insurance collected is $27.54 per acre higher than the unexpected economic loss which exceeds 25 percent. These two results imply that, in the free market scenario, collections under MPCI exceed the associated unexpected economic loss.

Turning to GRP insurance, 15 percent of the 339 observations in which GRP insurance is not collected in the free market scenario had an unexpected economic loss greater than 10 percent. For these 51 observations, average unexpected loss greater than 10 percent is $21.26 per acre. The comparable numbers for MPCI at the 25 percent deductible are two percent and $4.63 per acre. These results suggest that GRP is more prone than MPCI to the occurrence of situations in the free market where insurance is not collected even though unexpected economic loss exceeds the insurance deductible.

Differences between insurance collections and unexpected economic loss are generally smaller in the farm program scenario for both MPCI and GRP. In general, GRP results in more discrepancy in the farm program scenario between unexpected economic loss and insurance collections than does MPCI.

To further examine the implications for crop insurance, an actuarial breakeven cost of MPCI and GRP is determined by dividing the total dollar amount collected by the total number of insurance observations (i.e., 472). Thus, all farm operators are assumed to purchase insurance each year.

Comparable calculations are made for the unexpected economic loss resulting from yield variation. Specifically, once unexpected economic loss exceeds 10 (25) percent of expected gross revenue at planting, an amount is collected equal to the unexpected economic loss in excess of the deductible. Hereafter, these calculations will be referred to as yield revenue insurance.

Annual breakeven premium for MPCI, ignoring administration costs, is $9.84 per acre with a 25 percent deductible (Table 4). Annual breakeven premium for GRP is $15.60 per acre with a 10 percent deductible. At a 25 percent deductible, GRP's cost is $6.21 per acre. The lower cost for GRP than MPCI at the same deductible is consistent with Miranda's arguments that adverse selection is lower in a county yield program.

Under the free market scenario, breakeven cost for yield revenue insurance with a 25 percent deductible is 48 percent less than the comparable breakeven cost for MPCI. Furthermore, the breakeven cost for yield revenue insurance with a 25 percent deductible is also smaller than the breakeven cost for GRP with a 25 percent deductible in the free market scenario.

When farm programs are considered, the actuarial breakeven costs for yield revenue insurance is $10.56 with a 25 percent deductible[11]. This breakeven costs is slightly higher than the breakeven cost for MPCI with a 25 percent deductible, but smaller than the breakeven cost for GRP with a 10 percent deductible. The comparable cost for MPCI and yield revenue insurance reflects the relatively close match between MPCI collections and unexpected economic loss in the farm program scenario.

Except for GRP at the 10 percent deductible in the free market scenario, all insurance programs reduce the variability of realized gross income compared to the no insurance situation (Table 4). The standard deviation associated with GRP insurance is at least 10 percent higher than the standard deviation associated with MPCI and yield revenue insurance. MPCI and yield revenue insurance have similar standard deviations.

Without insurance, gross income is more variable when farm price and income support programs exist than when farm programs do not exist. However, with all three types of insurance, variability is lower in the farm program scenario than in the free market scenario at the 10 percent deductible. Variability is similar between the two scenarios at the 25 percent deductible. Thus, insurance is relatively more important in stabilizing gross income when farm price and income support programs exist[12].

## SUMMARY, CONCLUSIONS, AND IMPLICATIONS

Collections under current federal crop insurance programs are based on yield loss, but insurance is an economic good purchased to protect against the unexpected economic loss which results from physical loss, not against physical loss per se. A conceptual model reveals that substantive differences can exist between the deviation in an individual farm operator's yield from that expected at planting and the associated unexpected economic loss or gain in a market without farm price and income support programs (i.e., free market). The difference arises because an individual farm operator's yield loss or gain is often part of a wide-spread natural disaster or good weather. Thus, unexpected economic loss associated with yield loss for an individual farm operator is a function of not only the unexpected change in the operator's yield, but also the unexpected change in the value of the crop engendered by a wide-spread natural disaster or good weather.

Unexpected economic loss can differ substantially between the free market and a market with farm price and income support programs. The reason is that unexpected changes in national yield can cause the value of the crop and deficiency payments to move in opposite directions.

Empirical investigation of corn yields for a sample of Ohio farm operators support these conceptual arguments. Furthermore, a comparison of insurance collected under current federal crop insurance programs with unexpected economic loss reveals (1) that the Group Risk Plan (GRP) payout structure is further removed from unexpected economic loss than Multiple Peril Crop Insurance's (MPCI) payout structure, (2) that MPCI tends to pay out more insurance than the associated unexpected economic loss in he free market scenario, and (3) that MPCI more closely matches unexpected economic oss in the farm program scenario than in the free market scenario. Reflecting the last :wo findings, actuarial breakeven cost of compensating for unexpected economic loss resulting from yield variation was nearly identical to the breakeven cost of MPCI in the farm program scenario but 40 - 50 percent cheaper than the breakeven cost of MPCI in the free market.

These results and conclusions only apply to Ohio corn over four years. Therefore, the analysis needs to be expanded to other crops, years, and locations. Nevertheless, the analysis points to several implications for crop insurance.

Because GRP's payout structure is further removed from unexpected economic loss than MPCI's payout structure, farm operators probably will perceive it as unfair relative to MPCI, and thus be reluctant to purchase it.

While its payout structure should be modified to more closely match unexpected economic loss, MPCI currently provides a reasonable risk management tool for crops eligible for price and income support payments. However, a new MPCI contract should be designed to account for the different unexpected economic loss situation faced by crops which do not have farm support programs. Consistent with unexpected economic loss from yield variation in a free market, the new contract should base collections upon differences between percent unexpected change in national yield and individual operator's yield relative to yield expected at planting.

This proposed version of MPCI can be launched by requiring that insurance can be collected only when the farm operator experiences an unexpected yield decline which

; 25 percent (or some other number) more than the unexpected change in national yield. 'or example, assume realized U.S. yield is 10 percent less than expected average U.S. ield at planting time. Thus, for an operator to collect insurance, his/her realized yield nust be 35 percent or more below expected yield at planting. This insurance contract ıssumes a price change coefficient of 1.0. While the true price change coefficient is not mown, a value of 1.0 is close to the value empirically estimated in this paper.

The new MPCI contract should create a fairer and cheaper insurance program for crops which have no farm support programs. Consequently, participation should increase, government subsidies should decline, and the need for ad hoc disaster insurance should diminish. Note that these crops include soybeans in most years as well as flex acres of crops which have deficiency payment programs.

A last implication is that crop insurance based on unexpected economic loss should reduce the incidence of market failure from an insurance perspective. The reason is that the market failure factor, i.e. widespread decline in yield over a large area, is incorporated into the insurance contract. Consequently, the possibility for successful private insurance should increase. This implication needs further exploration.

## ENDNOTES

. A farm operator can sell crops in the cash market either at or after harvest. Iowever, any change in cash price after harvest is a return to storage, not a return to ›lanting the crop. Risks associated with storage are not part of the risk associated with ›roduction, and thus should be insured separately.

2. Beginning with the 1991 crop year, 15 percent of the acreage base is designated as flexible acres. Flexible acres can be planted to any crop except fruits and vegetables. Crops planted on flexible acres are eligible for price support loans (if available), but can not receive deficiency payments (USDA, June 1991, p. 35).

3. It is important to note that this analysis focuses only on the variability in income due to the variability in yield. Income can vary for reasons other than yield variability. Hence, this analysis is not concerned with revenue insurance, but with insuring revenue variation arising only from yield variation.

4. Survey respondents were asked for 1991 payment yield and 1991 expected yield only on land which they owned. In contrast, yield reported for 1986, 1987, 1988, and 1990 was the average for all the farm operator's land, both owned and rented. Since farm operators tend to rent land in the same local in which they own land, a high correlation is likely to exist between yields on owned and rented land. To examine the validity of this assumption, an analysis was conducted using the 28 farm operators who only owned land in all four years. The results were similar.

5. A trend-line projection based on yields for the previous 10 years was also used. Results for the two methods were similar for 1986, 1987, and 1988, but differed for 1990. The drought-reduced yield of 1988 lowered the trend-line projection for 1990 to 113.1 bushels per acre. Hence, the five year moving average was selected because its 1990 yield was consistent with the upward trend in expected yields for the three previous years. The same trend-line projection method was also examined for Ohio's expected yield. Results and conclusions mirror those for the U.S.

6. A correlation of 0.75 existed between percent change in new crop yield and percent change in estimated consumption of the new crop. Therefore, new crop consumption is not included in the regression.

7. A sensitivity test of the price change coefficient was conducted. Specifically, the aggregate demand price flexibility for corn implied by the Food and Agricultural Policy Research Institute's (FAPRI) economic model was used (Westhoff, et al.). This price flexibility was derived as the weighted average demand elasticity for feed, food, gasohol, exports, and free stocks. The weighting factor was the number of bushels in each category during the model's base year of 1988/89. The derived FAPRI implied price flexibility equalled -3.32. Despite the large difference from the approximate -0.80 price change coefficient used in this paper, results were similar.

8. As a sensitivity test, the actual Ohio cash basis during that year's harvest was used instead of the average basis for the five previous crops. Results were similar.

9. Despite relatively large differences between expected and realized national yields in 1986 and 1987, the distribution of unexpected gross revenue change in the farm program scenario does not mirror the distribution of unexpected yield changes more closely than does the distribution of unexpected gross revenue change in the free market scenario. This observation differs from that for 1988 largely because expected and realized per bushel deficiency payment were at their maximum value in 1986 and 1987. Hence, the decline in market value of corn caused by the unexpected increase in national yield could not be offset by an unexpectedly higher deficiency payment.

10. If farm specific records are not available, APH yield is calculated using county average yields (Lovell and Benson, p. 1).

11. The 1993/94 target price of $2.75 and loan rate of $1.72 is also used for all four years in place of the contemporaneous loan rate and target price for each year. Breakeven cost for yield revenue insurance in the deficiency payment scenarios are $11.40 and $23.48 at the 25 and 10 percent deductible, respectively.

12. Further analysis reveals that it is the deficiency payment and not the nonrecourse loan which increases the variability of crop income relative to the variability in a free market. This finding provides insight into a question which has puzzled policy analysts: Why did disaster insurance emerge as a major farm policy issue in the mid-1970's? Specifically, the advent of deficiency payments in 1973 increased the variability of crop income, and thus the need for crop insurance.

**TABLE 1. PERCENT DIFFERENCE BETWEEN ACTUAL AND EXPECTED CORN YIELDS FOR FARM OPERATORS BY YEAR, OHIO, 1986, 1987, 1988, AND 1990**

| YEAR | PERCENT CHANGE IN YIELD FROM THAT EXPECTED AT PLANTING[a,b] | | | | | | |
|---|---|---|---|---|---|---|---|
| | < -25% | -10.1 to -25% | -10% to 0 | 0 to 10% | 10.1 to 25% | > 25% | Total |
| | ---------------------------Percent of Farm Operators ------------------------- | | | | | | |
| 1986 | 0.0 | 5.1 | 4.2 | 17.8 | 40.7 | 32.2 | 100 |
| 1987 | 6.8 | 16.1 | 19.5 | 30.5 | 19.5 | 7.6 | 100 |
| 1988 | 69.5 | 23.7 | 5.1 | 1.7 | 0.0 | 0.0 | 100 |
| 1990 | 3.4 | 12.7 | 41.5 | 28.0 | 13.6 | 0.8 | 100 |
| All Years | 19.9 | 14.4 | 17.6 | 19.5 | 18.5 | 10.2 | 100 |

[a] Calculated as actual yield divided by expected yield.

[b] There are 118 observations in each year for a total of 472 observation over all four years.

SOURCE: Ohio Farm Longitudinal Survey and Original Calculations

**TABLE 2. PERCENT UNEXPECTED CHANGE IN GROSS REVENUE FOR FARM OPERATORS RESULTING FROM YIELD VARIATION BY YEAR, OHIO CORN PRODUCTION, 1986, 1987, 1988, AND 1990**

| MARKET SCENARIO BY YEAR | PERCENT UNEXPECTED CHANGE IN GROSS REVENUE[a] | | | | | | |
|---|---|---|---|---|---|---|---|
| | < -25% | -10.1 to -25% | -10% to 0 | 0 to 10% | 10.1 to 25% | > 25% | Total |
| Free Market | ---Percent of Farm Operators--- | | | | | | |
| 1986 | 0.8 | 5.9 | 13.6 | 33.1 | 28.8 | 17.8 | 100 |
| 1987 | 10.2 | 21.2 | 32.2 | 20.3 | 12.7 | 3.4 | 100 |
| 1988 | 37.3 | 19.5 | 12.7 | 11.0 | 16.1 | 3.4 | 100 |
| 1990 | 3.4 | 13.6 | 42.4 | 27.1 | 12.7 | 0.8 | 100 |
| All Years | 12.9 | 15.1 | 25.2 | 22.9 | 17.6 | 6.4 | 100 |
| Farm Program | | | | | | | |
| 1986 | 0.0 | 0.8 | 8.5 | 32.2 | 44.1 | 14.4 | 100 |
| 1987 | 0.0 | 14.4 | 28.0 | 39.0 | 17.0 | 1.7 | 100 |
| 1988 | 61.9 | 28.8 | 7.6 | 1.7 | 0.0 | 0.0 | 100 |
| 1990 | 2.5 | 11.0 | 44.1 | 28.8 | 12.7 | 0.8 | 100 |
| All Years | 16.1 | 13.8 | 22.1 | 25.4 | 18.5 | 4.2 | 100 |

[a] There are 118 observations in each year for a total of 472 observation over all four years.

SOURCE: Ohio Farm Longitudinal Survey and Original Calculations

**Table 3. Relationship Between Unexpected Economic Loss Resulting from Yield Variation and Insurance Collected, Free Market and Farm Program Scenarios, Ohio Corn, 1986, 1987, 1988, and 1990.**

| Farm Operator Situation | Federal Crop Insurance Program by Scenario | | | |
|---|---|---|---|---|
| | Multiple Peril (25%)[a] | | Group Risk Plan (10%)[a] | |
| | Free Market | Farm Program | Free Market | Farm Program |
| Insurance Collected (No. of Observations) | 93 | 93 | 133 | 133 |
| Unexpected Economic Loss < Deductible | | | | |
| Percent of Observations | 40.86% | 18.28% | 39.10% | 12.03% |
| Average Insurance Collected | $25.79 | $10.55 | $49.92 | $27.52 |
| Unexpected Economic Loss > Deductible | | | | |
| Percent of Observations | 59.14% | 81.72% | 60.90% | 87.97% |
| Average Insurance Collected | $67.27 | $58.73 | $58.84 | $59.16 |
| Average Unexpected Economic Loss > Deductible | $39.73 | $65.56 | $57.01 | $86.65 |
| Insurance Not Collected (No. of Observations) | 379 | 379 | 339 | 339 |
| Percent whose Unexpected Economic Loss > Deductible | 1.58% | 0.00% | 15.04% | 7.08% |
| Average Unexpected Economic Loss > Deductible | $4.63 | $0.00 | $21.26 | $21.93 |

[a] Percent deductible

SOURCE: Ohio Farm Longitudinal Survey and Original Calculations

**TABLE 4. BREAKEVEN ACTUARIAL COST AND GROSS INCOME VARIABILITY UNDER ALTERNATIVE CROP INSURANCE PROGRAMS, FREE MARKET AND FARM PROGRAM SCENARIOS, OHIO CORN, 1986, 1987, 1988, AND 1990.**

| Insurance Program | Free Market Scenario | | Farm Program Scenario | |
|---|---|---|---|---|
| | Actuarial Cost | Average Standard Deviation of Gross Income | Actuarial Cost | Average Standard Deviation of Gross Income |
| | $ / Acre | | | |
| No Insurance | NA[a] | 42.29 | NA[a] | 52.00 |
| MPCI | | | | |
| 10% Deductible | 19.62 | 37.13 | 19.62 | 23.79 |
| 25% Deductible | 9.84 | 33.36 | 9.84 | 35.14 |
| GRP | | | | |
| 10% Deductible | 15.60 | 43.16 | 15.60 | 34.70 |
| 25% Deductible | 6.21 | 39.88 | 6.21 | 42.41 |
| Yield Revenue | | | | |
| 10% Deductible | 12.08 | 31.06 | 22.59 | 22.13 |
| 25% Deductible | 4.69 | 35.82 | 10.56 | 33.88 |

[a] Not Applicable

SOURCE: Ohio Farm Longitudinal Survey and Original Calculations

**REFERENCES**


Cross, Tim and Laurence Crane. "What is Multiple Peril Crop Insurance." *Risk Management Planning for 1993: A Series of Fact Sheets*. Federal Crop Insurance Corporation and Extension Advisory Council. Fact Sheet #3. January 1993.

Lovell, Ashley C. and Fred Benson. "How do you Calculate the 'APH' Yield." *Risk Management Planning for 1993: A Series of Fact Sheets*. Federal Crop Insurance Corporation and Extension Advisory Council. Fact Sheet #7. January 1993.

Lovell, Ashley C. and Daniel B. Smith. "Crop Insurance: More Flexible in 1993." *Risk Management Planning for 1993: A Series of Fact Sheets*. Federal Crop Insurance Corporation and Extension Advisory Council. Fact Sheet #5. January 1993.

Miranda, Mario J. "Area-Yield Crop Insurance Reconsidered." *American Journal of Agricultural Economics*. 73(1991): 233-42.

Ohio Agricultural Statistics Service. *Ohio Agricultural Statistics and Ohio Department of Agriculture Annual Report*. Various years, 1986-1991.

Skees, Jerry R., Timothy Collins, and Fred J. Benson. "Training Manual Group Risk Plan: Pilot Test for Soybeans." University of Kentucky, Department of Agricultural Economics. 1992.

U.S. Department of Agriculture, Economic Research Service, Foreign Agriculture Service. "World Supply and Demand Estimates." Various issues, 1975-1990.

U.S. Department of Agriculture, Federal Crop Insurance Corporation. "GRP Soybean Group Risk Plan Handbook." October 1992.

U.S. Department of Agriculture. *Agricultural Statistics 1992*. United States Government Printing Office. Washington: 1992.

U.S. Department of Agriculture, Office of Public Affairs and Office of Public Liaison. "Farm Bill Issues: Background Facts." May 1990.

Westhoff, Patrick, Robert Baur, Deborah L. Stephens, and William H. Meyers. "FAPRI U.S. Crops Model Documentation." Iowa State University, Center for Agricultural and Rural Development Technical Report 90-TR 17. December 1990.

Williams, Jr., C. Arthur, George L. Head, Ronald C. Horn, and G. William Glendenning. *Principles of Risk Management and Insurance*. American Institute for Property and Liability Underwriters, Inc. 1982.